Caucasian-German School and Workshop
on Hadron Physics

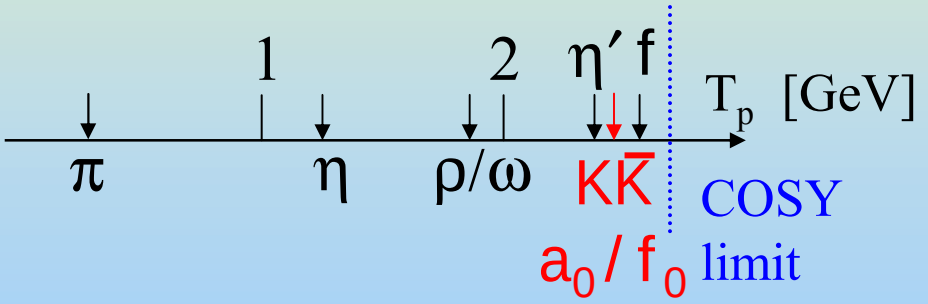
Light Scalar Meson Production at COSY

Vera Kleber

Forschungszentrum Jülich/
Universität zu Köln

COSY

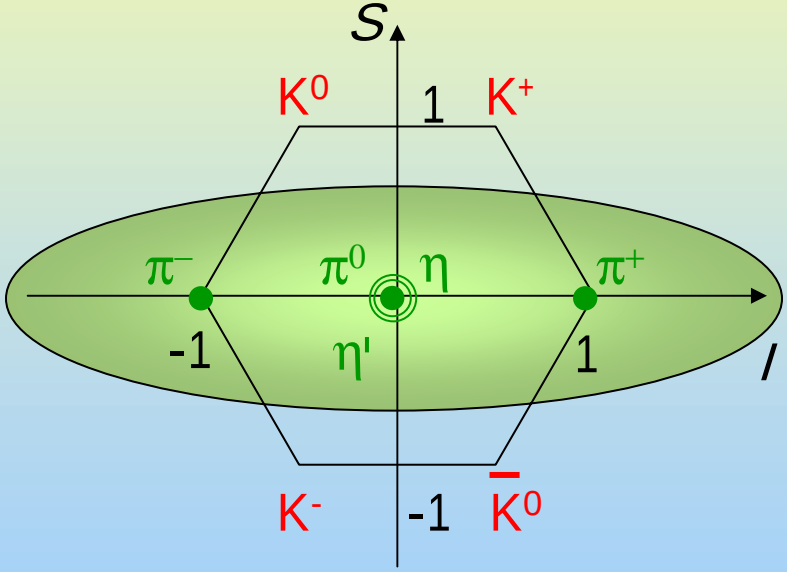
Accessible Reactions
pp -> ppX (X=Meson)
at COSY



Meson Nonets

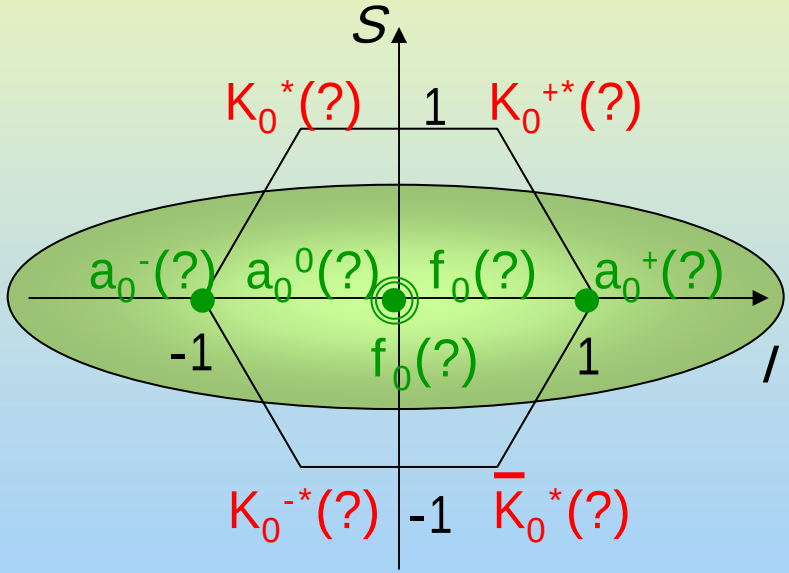
Nonet of pseudo scalar mesons

$J^P=0^-$



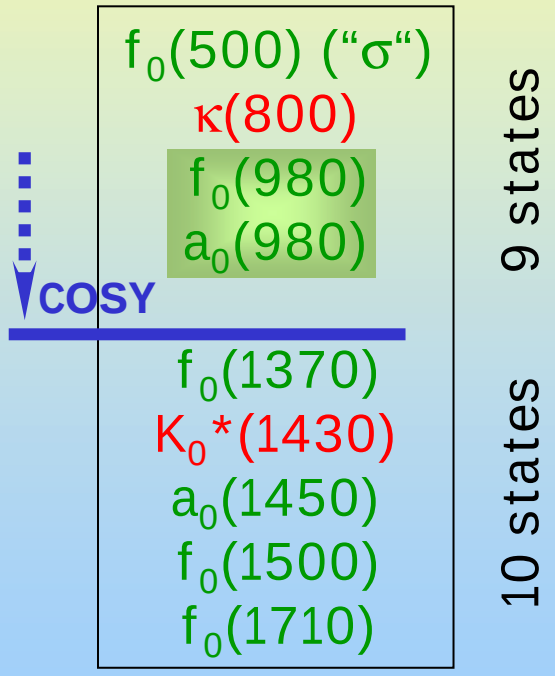
Nonet of light scalar mesons

$J^P=0^+$



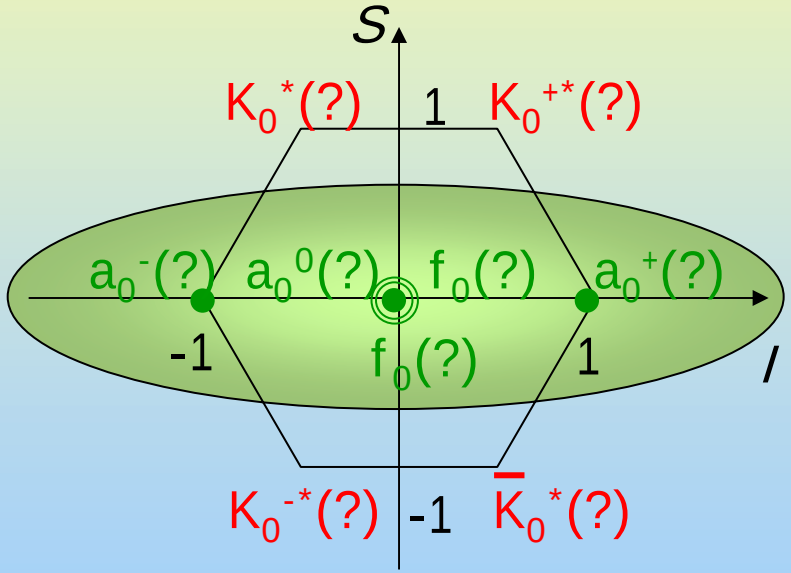
The Light Scalar Resonances

Possible candidates



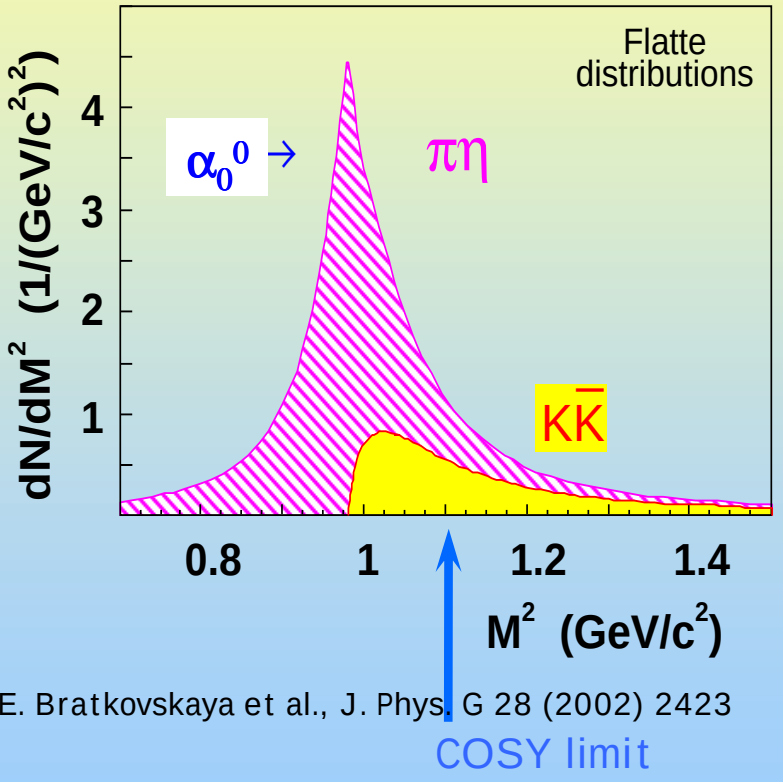
Nonet of light scalar mesons

$J^P=0^+$



The a_0 and f_0 Resonance

	a_0 / f_0
Mass	984.7±1.2 / 980±10 MeV
Width	50 – 100 / 40 – 100 MeV
Decays	$\pi\eta/\pi\pi$ dominant
	$K\bar{K}/K\bar{K}$ seen
	$\gamma\gamma/\gamma\gamma$ seen



E. Bratkovskaya et al., J. Phys. G 28 (2002) 2423

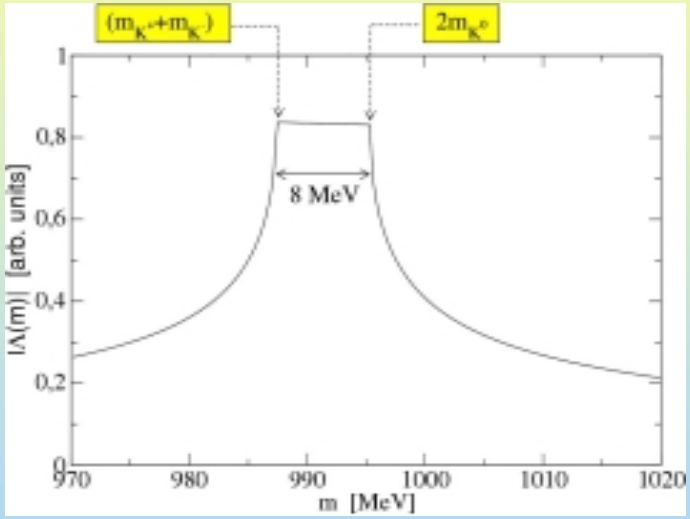
PDG: E. Eidelman et al., Phys. Lett. B 594, 1 (2004)

a_0 / f_0 Nature

What is their nature?

$q\bar{q}$ state
or
4 quark state
or
$K\bar{K}$ molecule

$d\sigma/dm \sim |\Lambda(m)|^2$

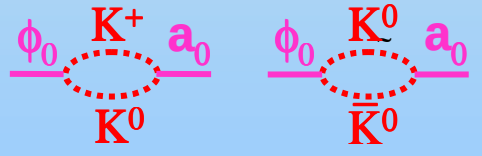


N.N. Achasov et al., Phys. Lett. B 88, 367 (1979)

Which observable to measure at COSY?

$d\sigma/dm_{\pi\eta}$ $(dd \rightarrow \alpha\pi^0\eta)$

$\rightarrow$ a_0 / f_0 mixing amplitude

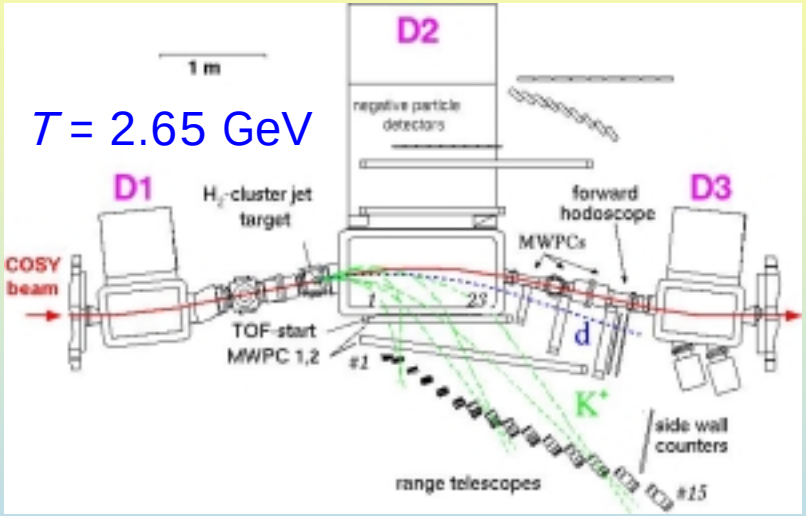
L = 

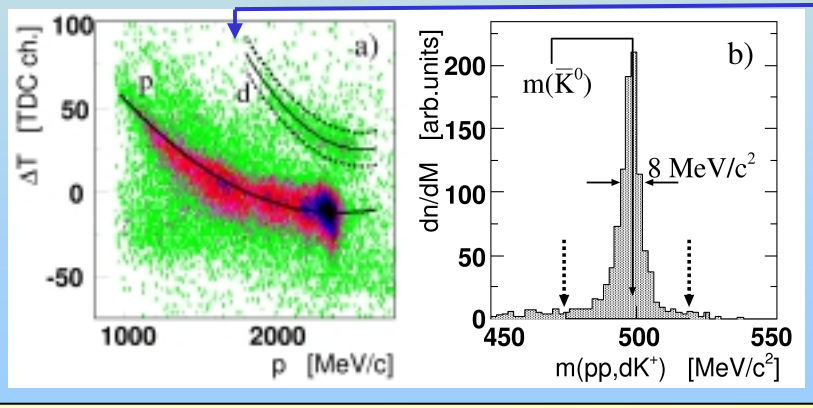
+ others

$K\bar{K}$ Production at COSY

Reaction	Where?	Excess Energy [MeV]	Result / Status
$pp \rightarrow d K^+\bar{K}^0$	ANKE	48, 105	a_0^+ channel dominates
$pp \rightarrow pp K^+K^-$	COSY-11 ANKE	10, 17, 28, 51, 67, 108	a_0^0/f_0 contribution?? f Production
$pd \rightarrow {}^3He K^+K^-$	MOMO	35, 40, 56	a_0^0/f_0 contribution?? f Production
$pn \rightarrow d K^+K^-$	ANKE	30 – 90	a_0^0/f_0 contribution ? f Production

Identification of $pp \rightarrow dK^+\bar{K}^0$





FD-SD coincidence measurement

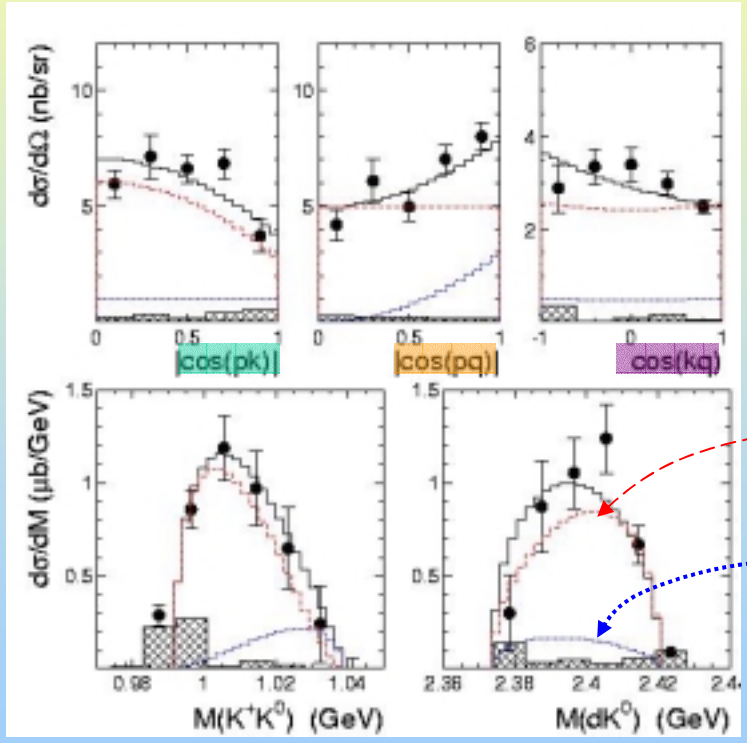
- Identification of K^+ mesons via TOF, ΔE and particle momenta
- Identification of deuterons via TOF and particle momenta
- Identification of $pp \rightarrow dK^+\bar{K}^0$ via dK+ missing mass

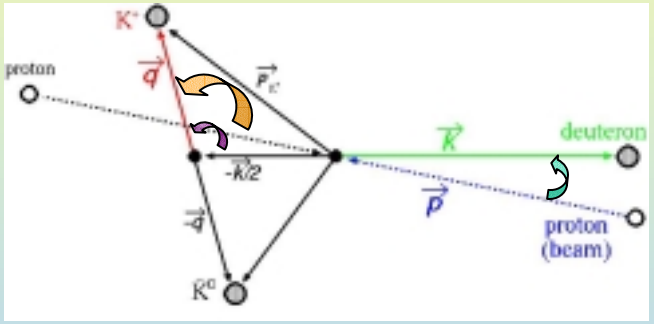
$\rightarrow$ ~ 1000 $dK^+\bar{K}^0$ events

$pp \to dK^+\bar{K}^0$ @ ANKE

T =2.65 GeV (Q =48 MeV)

$\sigma_{tot}(pp \to dK^+\bar{K}^0) =$
$(38 \pm 2_{stat} \pm 14_{sys})$ nb





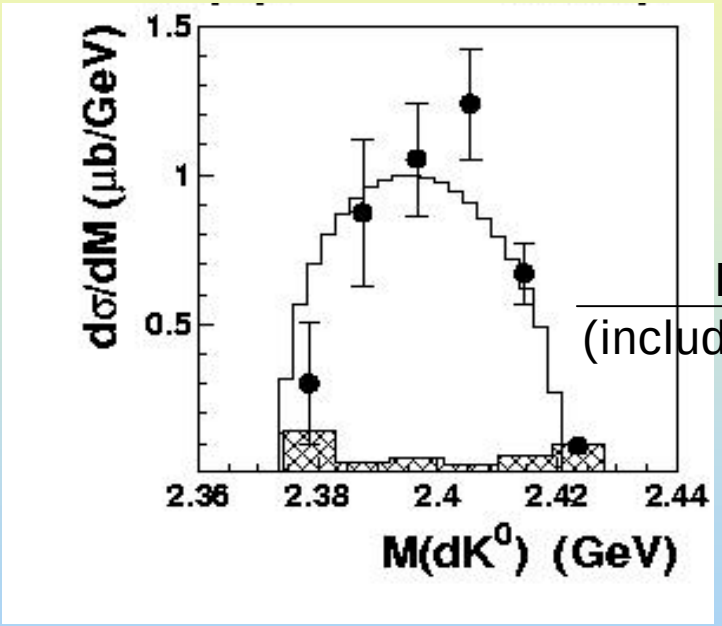
Fit:

$[(K\bar{K})_P d]_S + [(K\bar{K})_S d]_P$

$\to$ 83% a^+_0channel

V.Kleber et al., Phys. Rev. Lett. 17, 172304

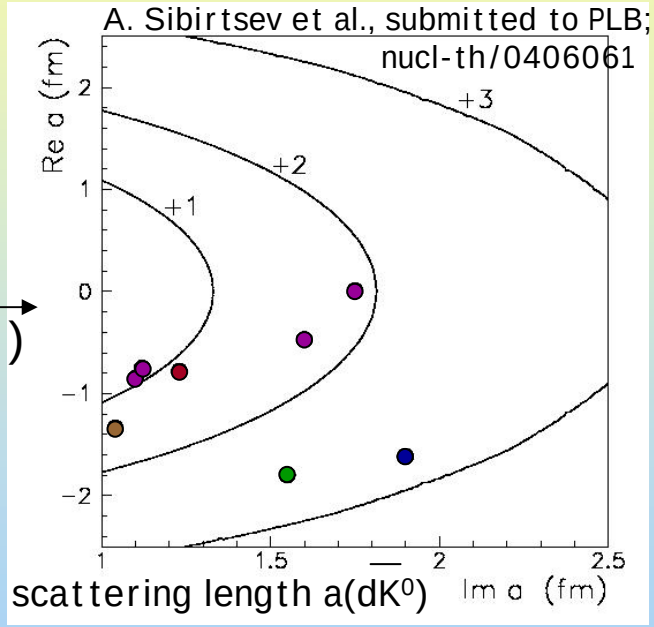
$D\bar{K}^0$ FSI



Fit
(including FSI)

χ^2

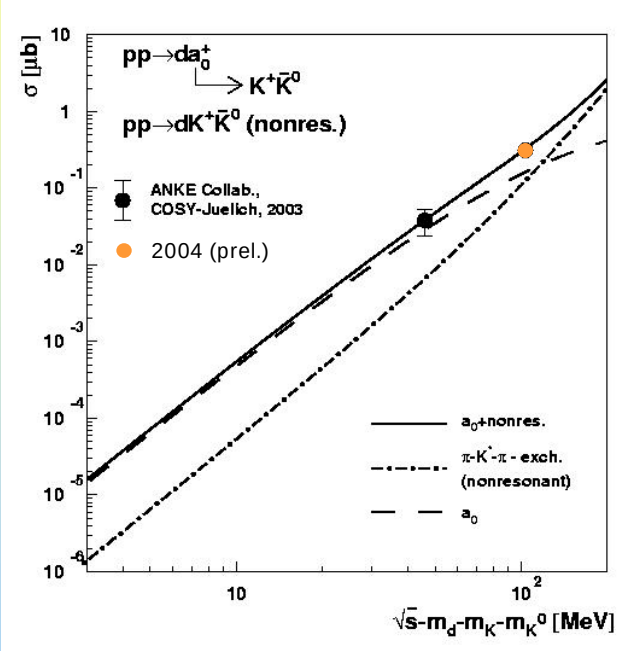
A. Sibirtsev et al., submitted to PLB;
nucl-th/0406061



FSI included via Watson factor

A.Bahaoui et al., Phys. Rev. C 66 (2002) 057001
Phys. Rev. C 68 (2003) 064001
A.Deloff, Phys. Rev. C 61 (2000) 024004
V.Yu.Grishina et al., nucl-th/0402093
S.S.Kamelov et al., Nucl. Phys. A 690 (2001) 494
M.Torres et al., Phys. Lett. B 174 (1986) 213

In Progress: T_p=2.83 GeV

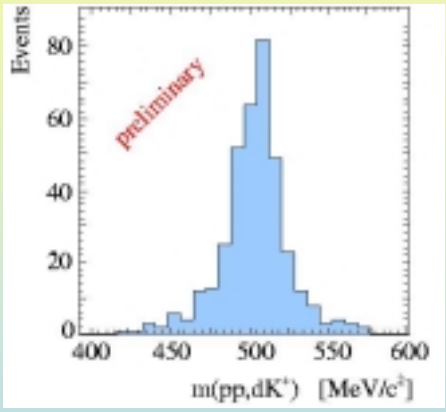


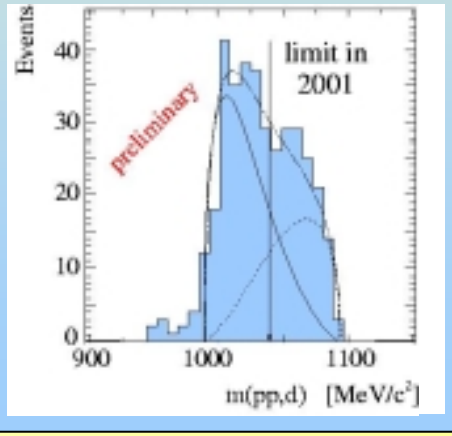
V. Grishina et al., EPJA in print, nucl-th/0402093

Preliminary:

$\sigma_{tot}(pp \longrightarrow dK^+\bar{K}^0)$ = 330 nb

T_p = 2.83 GeV, Q = 105 MeV

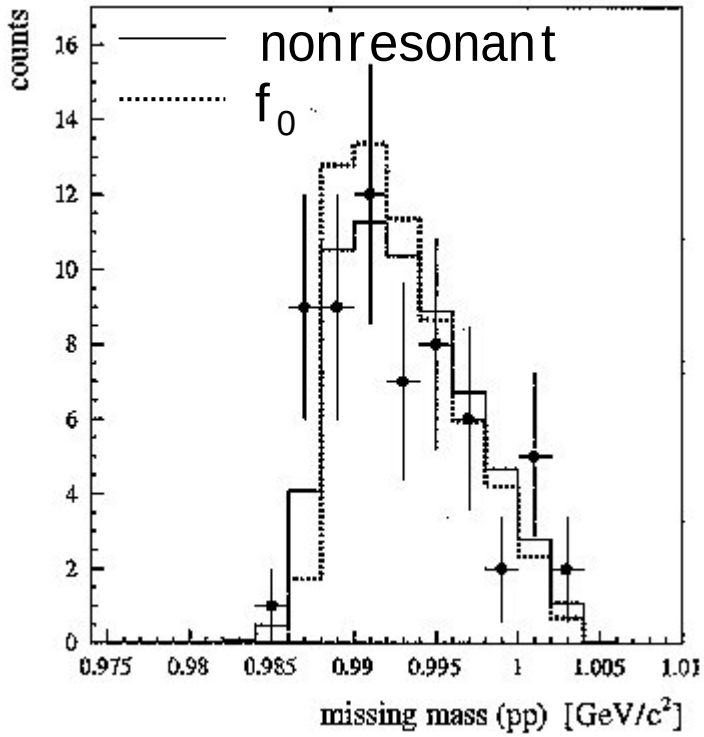




$K\bar{K}$ Production at COSY

Reaction	Where?	Excess Energy [MeV]	Result / Status
$pp \rightarrow d K^+\bar{K}^0$	ANKE	48, 105	a_0^+ channel dominates
$pp \rightarrow pp K^+K^-$	COSY-11 ANKE	10, 17, 28, 51, 67, 108	a_0^0/f_0 contribution?? f Production
$pd \rightarrow {}^3He K^+K^-$	MOMO	35, 40, 56	a_0^0/f_0 contribution?? f Production
$pn \rightarrow d K^+K^-$	ANKE	30 – 90	a_0^0/f_0 contribution ? f Production

pp → pp K^+K^- @ COSY11/ANKE



P.Moskal et al., J. Phys. **G**. 29, 2235 (2003)

COSY–11

Q = 17 MeV
(below ϕ threshold)

$\sigma_{tot} = (1.80 \pm 0.27\ ^{+0.28}_{-0.35})$ nb

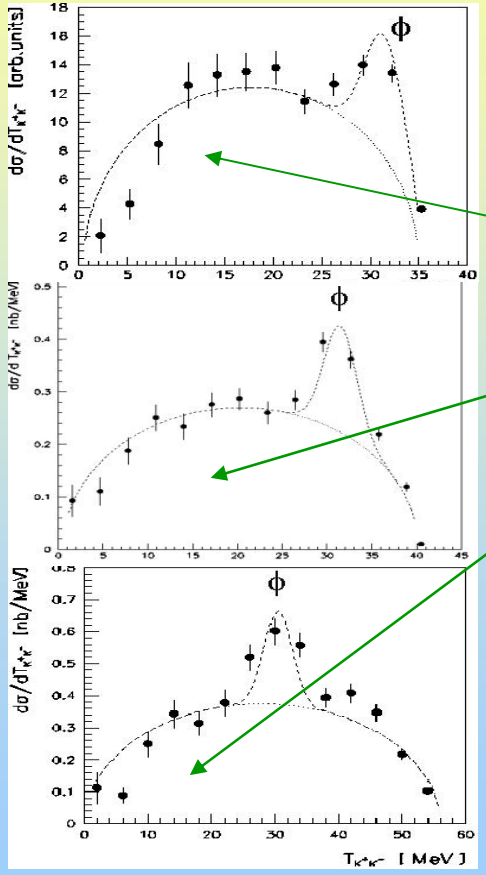
Still being analysed

- Q_{KK} = 10, 28 MeV COSY11
  (below f threshold)
- Q_{KK} = 51, 67, 108 MeV ANKE
  (above ϕ threshold)

$K\bar{K}$ Production at COSY

Reaction	Where?	Excess Energy [MeV]	Result / Status
$pp \rightarrow d K^+\bar{K}^0$	ANKE	48, 105	a_0^+ channel dominates
$pp \rightarrow pp K^+K^-$	COSY-11 ANKE	10, 17, 28, 51, 67, 108	a_0^0/f_0 contribution?? f Production
$pd \rightarrow {}^3He K^+K^-$	MOMO	35, 40, 56	a_0^0/f_0 contribution?? f Production
$pn \rightarrow d K^+K^-$	ANKE	30 – 90	a_0^0/f_0 contribution ? f Production

pd → ^{3}He K^+K^- @ MOMO



from: IKP Annual Report 2001

$\sigma(f) = (0.7 \pm 0.2)$ nb
$\sigma(K^+K^-) = (7.5 \pm 1.0)$ nb
Q =35 MeV

$\sigma(a_0 / f_0 \rightarrow K^+K^-) = ??$

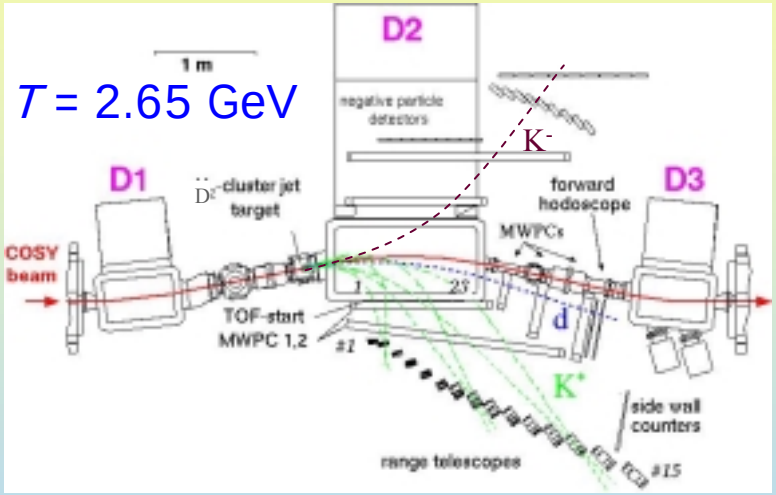
$\sigma(f) = (0.9 \pm 0.2)$ nb
$\sigma(K^+K^-) = (9.6 \pm 1.0)$ nb
Q =40 MeV

$\sigma(f) = (1.4 \pm 0.6)$ nb
$\sigma(K^+K^-) = (17.5 \pm 1.8)$ nb
Q =56 MeV

$K\bar{K}$ Production at COSY

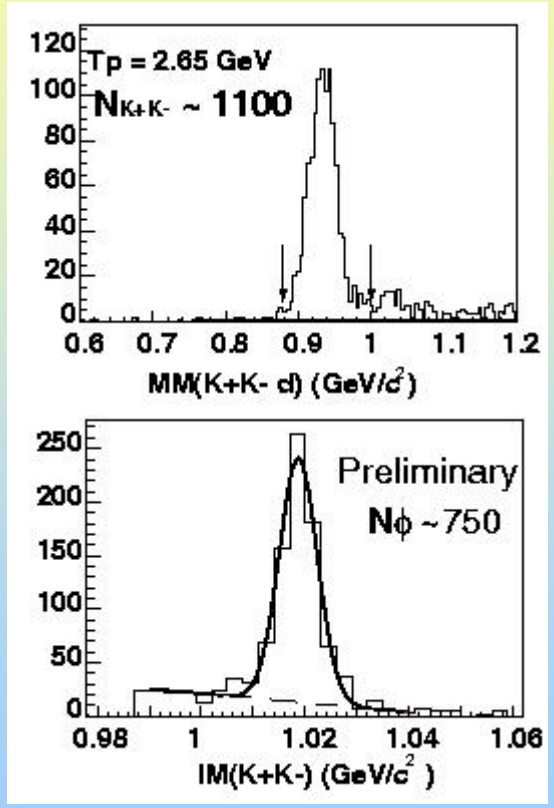
Reaction	Where?	Excess Energy [MeV]	Result / Status
$pp \rightarrow d K^+\bar{K}^0$	ANKE	48, 105	a_0^+ channel dominates
$pp \rightarrow pp K^+K^-$	COSY-11 ANKE	10, 17, 28, 51, 67, 108	a_0^0/f_0 contribution?? f Production
$pd \rightarrow {}^3He K^+K^-$	MOMO	35, 40, 56	a_0^0/f_0 contribution?? f Production
$pn \rightarrow d K^+K^-$	ANKE	30 – 90	a_0^0/f_0 contribution ? f Production

pn → dK⁺K⁻ @ ANKE



- D_2 as an effective neutron target
- $K^+ K^-$ d coincidence measurement

⟶ First data on ϕ-meson production on neutrons



(only part of the statistics)

Outlook

Planned measurements:

$dd \rightarrow \alpha K^+K^-$ @ ANKE

- reaction serves as isospin I=0 filter
- isospin conservation: f_0

Goals:

- cross section ($d\sigma/dm$)
- $K^-\alpha$ FSI ?

$dd \longrightarrow \alpha \pi^0 \eta$ @ WASA

- forbidden if isospin is conserved
- mixing $f_0 \leftrightarrow a_0$

Goals:

- cross section ($d\sigma/dm$)
- $\frac{d\sigma/dm\ (dd \longrightarrow \alpha \pi^0 \eta)}{d\sigma/dm\ (dd \longrightarrow \alpha K^+K^-)}$

  $\longrightarrow$ |mixing amplitude|^2

Summary

Light Scalar Meson Production at COSY

ppK^+K^-	$\rightarrow$	unclear
$dK^+\overline{K}^0$	$\rightarrow$	a_0^+ channel dominates
more to come	$\rightarrow$	final goal: mixing amplitude

COSY Student Program

13-16 September 2004

Institut für Kernphysik,
Forschungszentrum Jülich

Point of Discussion:

QCD and its Phenomenological Implications
Symmetries and Symmetrie-Breaking
New Detector and Target Concepts
Data Analysis
Synchrotrons and Storage Rings
Polarized and Cooled Beams

Organizers: K.Brinkman, M.Büscher,
A.Gillitzer, C.Hanhart, V.Kleber, S.Krewald,
A.Lehrach, J.Ritman, E.Roderburg, H.Ströher